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NEW TECHNOLOGY REQUIRED TO IMPLEMENT U.S. ANTI-PERSONNEL LANDMINE POLICY

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ABSTRACT

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Current U.S. APL policy seeks to accomplish three major objectives. First, it seeks to ensure that American military personnel will have the tools they need to accomplish their global responsibilities. Second, it seeks to ensure that U.S. APL do not cause unintended casualties. It also expands the U.S. role in reducing casualties by non-U.S. landmines. Third, it seeks a responsible treaty to ban APL without unduly compromising military concerns. The objective of this paper is to demonstrate how the development and application of improved mine, countermine, and demining technology could facilitate, significantly in some cases, the three major APL policy objectives of the United States.

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Modern landmines initially appeared during the First World War to counter the first generation of tanks. To prevent these anti-tank (AT) landmines from being easily removed, the belligerents developed anti-personnel landmines (APL). Later, warring nations developed APL specifically for use against dismounted infantry. Throughout the first half of the 20th Century landmines continued to be employed only against military targets. Beginning in the 1960s however, landmines were intentionally used against civilian as well as military targets. Today experts estimate that between 40 and 110 million landmines are emplaced. Most of these landmines are APL. As a result of this saturation and indiscriminate use, approximately 12,000 to 25,000 people are killed or maimed every year. Many of these casualties are civilian adults and children.[1]

It is likely that these civilian casualties and APL will continue to proliferate. Starting at $3 each, most APL are affordable and readily available to even the poorest country or group. Experts estimate that up to 100 million landmines, the majority APL, are stockpiled in inventories throughout the world. Moreover, APL are effective, especially in low intensity conflict, the most prevalent form of warfare. Many of the actors involved in this type of conflict use APL indiscriminately.[2] Once emplaced, these mines generally remain dangerous for years. Finally, technical advances in landmines have not been followed with equal advances in mine countermeasures. This imbalance

provides one area where the least technically developed combatant can compete with the most developed adversary.[3]

To stem civilian losses from APL, two solutions have gained broad international support. The first is to eliminate the use of APL. The second is to remove the emplaced mines. The most effective attempt to ban APL has been made by an unusual combination of governmental and non-governmental actors. This coalition and their forum, dubbed the Ottawa Process, rapidly produced an international treaty to ban APL signed by 122 countries on 3 December 1997.[4]

Although President Clifton called for an eventual international ban on APL in 1994, he did not sign the Ottawa treaty because of current U.S. APL policy. That policy is designed to accomplish three major objectives. First, it seeks to ensure that American military personnel will have APL, where and when legitimately needed to protect U.S. and coalition lives. Second, it seeks to ensure that U.S. use of APL will not cause civilian casualties. It also expands the U.S. role in reducing civilian casualties caused by non-U.S. landmines. Third, it seeks a responsible treaty to ban APL without unduly compromising military concerns.[5]

Today the technology of LANDMINE warfare ranges from Second World War industrial age technology to leading-edge information age technology. Although there are some exceptions and improvements, most American LANDMINE technology is at least

several generations behind the state-of-the-art. The objective of this paper is to demonstrate how the development and application of improved mine, countermine, and demining technology could facilitate, significantly in some cases, the accomplishment of the three major APL policy objectives of the United States.

I The Paradox of Current U.S. APL Policy

Of the three major U.S. policy objectives, the government has placed the most emphasis on the areas dealing with humanitarian concerns. In order to ensure American APL do not cause civilian casualties, the U.S. has banned APL export and capped their stockpiles at current levels. In addition the U.S. has discontinued the production of non self-destructing (NOD) APL. Stockpiles of NOD APL outside Korea will not be used and are to be rendered unusable by the end of 1999. There are also plans to modify Korea's NOD APL by mid-1998 to meet improved delectability standards established by the Conference on Conventional Weapons. Finally, in order to alleviate the humanitarian problems caused by non-U.S. APL, the United States will expand existing humanitarian demining efforts. In this regard, the U.S. recently announced a campaign to rid the world of emplaced landmines through demining by 2010.[6]

Nevertheless, the paradox in U.S. policy remains. For while that policy recognizes a current legitimate military need for APL, it also stipulates that American APL use is to be severely restricted and is to end in 2006; self-destructing (SD) APL can

be used everywhere until 2003; NOD and SD APL in Korea until 2006. By 2006 the military is to develop an alternative to replace APL with one exception: mixed systems, or systems which use SD APL to protect SD AT mines, will be retained beyond 2006.[7]

The ultimate goal of U.S. policy is a responsible treaty to ban APL. Currently the U.S. is pursuing this treaty through the Conference on Disarmament (CD) by seeking a large, if not total, population of signatories. Especially important potential signatories are the APL-producing and APL-exporting countries, many of which are members of the CD. The U.S. is also seeking strong enforcement and verification procedures.[8]

II The Problems of Mine Warfare

It is difficult to separate APL issues from the larger category of mine warfare. The U.S. Army has traditionally organized the subject of mine warfare into three distinct areas: mine, countermine and demining. Mine and countermine are military activities. On the battlefield, landmines support countermobility functions, countermine activities support mobility functions. Demining is accomplished by civilians, most often indigenous, with assistance from the Department of Defense. Mine activities include the development, procurement, training, and use of landmines. Countermine actions include the development, procurement, training, and use of military countermeasures to overcome the use of landmines only in specific areas of military significance. Countermine activities include breaching,

countermeasures under fire, and clearing, countermeasures not under fire. Demining includes the development and procurement of demining technology and the training of civilian deminers to completely remove and destroy all landmines from an affected area. Countermeasures include detecting, reporting, removing and destroying landmines.[9]

Mine

Landmines are generally used to hinder or direct an enemies mobility. Mines are classified by use as anti-personnel or anti-tank. APL can be constructed from a variety of materials but most include at least some metal. A few APL are constructed entirely of plastic. APL are detonated by a variety of means but most commonly by direct pressure or trip wire. While most APL are NOD, the majority of U.S. APL are SD and many are also self-destructing and self-deactivating (SDSD). The self-destruct feature detonates the mine after a designated period of time from 4 hours to 15 days. The self-deactivating feature renders the mine harmless when the battery expires after no more than 90 days. SDSD technology makes U.S. mines equally effective against military targets while greatly reducing the potential for civilian casualties. Once these mines are deactivated, the dangers and costs of humanitarian demining operations are virtually eliminated.[10]

NOD APL cause a significant number of unintended casualties every year. Although many of these casualties are civilian,

soldiers are also victims of APL especially during conflict. There are also other disadvantages. For instance, APL are difficult to track, limit dismounted freedom of maneuver, cannot distinguish friend from foe, and contribute to fratricide.[11]

Mine Countermeasures

Many variables combine to make mine detection very complex and by far the most difficult countermeasure problem to solve technically. Mines are configured with a large variety of housings, explosives and fuses. Experts have cataloged over 2,500 different combinations.[12] Mines are emplaced beneath or on the earth's surface. The earth itself varies tremendously from rocky soil to rich organic loam. Moisture and temperature change constantly with the time of day and seasons.

In addition to the technical challenge, countermeasure technology has also been underfunded, especially when compared with funding for mines.[13] Part of the funding problem has been a lack of concern except during a crisis involving mines such as events in Somalia and Bosnia which demonstrated the potential of mines to slow and even temporarily halt operations. Different requirements for military countermine and humanitarian demining have also diffused the focus of mine countermeasures. More than one technology will be needed to solve these problems; but no one agency has coordinated the various components of this complex task.[14]

Countermine

Countermine functions are used to facilitate friendly mobility through enemy mines. It includes detecting, breaching, clearing, marking, and reporting mines. In terms of detection, the AN/PSS-12 Mine Detector uses electromagnetic induction (EMI) technology and is the most advanced fielded U.S. system. To determine the exact location of a mine this sophisticated handheld metal detector is used in conjunction with a plastic probe.[15] The use of a metal detector and probe, however, requires the operator to be well within the mine's blast radius. This process is dangerous and slow and can only detect one mine at a time. Moreover, mines without metal cannot be detected by a metal detector. At the same time, a metal detector cannot discriminate between a mine with metal and any other buried metal object. Finally, some mines have fuses that are detonated by the magnetic field created by a metal detector.[16]

Breaching while mounted is accomplished explosively or mechanically. The M58 Mine Clearing Line Charge (MICLIC) or Mk 154 Triple Shot Line Charge systems propel an explosive line charge across a minefield with a rocket. The line charge is then detonated to set off or blast out mines in the breach lane. Both of these systems require soldiers to be in the proximity of the minefield and enemy fire. In addition, accuracy in mine destruction is sacrificed to speed and momentum. The result is

that these systems will normally fail to detonate all mines in the lane.[17]

Mechanical systems like the Track-Width Mine Roller (TWMR) and Full-Width Mine Rake (FWMR) are also used to breach minefields. These systems push mines out of the way or detonate them in place.[18] Mounted in front of a tank, the TWMR is not suited for all types of mines, soil or terrain. It did not work well during Desert Storm. The maneuverability and speed of the tank is dramatically reduced when fitted with a TWMR. The FWMR worked well during Desert Storm, but is also not suitable for all types of soil or terrain. The FWMR must be mounted on some type of a vehicle. It should be mounted on an armored breaching vehicle capable of keeping pace with tanks and infantry fighting vehicles. No currently fielded breaching vehicle meets these requirements.[19]

If a mine needs to be cleared, the first option is to disarm the mine. If it cannot be safely disarmed, the mine is destroyed in place. This process is dangerous because the soldier must expose the mine. It is also slow and laborious and when used on metallic mines, will scatter additional metal particles creating even more clutter.[20]

Enemy and friendly minefields require reporting so that friendly units will not run into them. In immature theaters, the current system is dependent on each person at each unit constantly reporting, tracking, sharing, and updating

information. Once reported, minefields are depicted on situational graphics. This system is not automated and demands constant vigilance to maintain the graphics and share the information with every member of the unit. The ability to rapidly emplace large numbers of minefields today can quickly overwhelm the ability to keep everyone updated.[21]

Demining

There is no standard demining technology. In general, the technology and procedures for demining are similar to those used in countermine operations except for breaching. But demining is more dangerous, slower, and more expensive. One of the biggest problems is the high number of false positives caused by clutter. More than 1,000 false alarms can be detected before an actual mine is discovered. The UN has established a standard of 99.6% for detecting and clearing mines for demining operations.[22] Although understandable, this standard is very difficult to meet. Demining operations typically lack the funding to field expensive equipment and many lack necessary support systems to maintain sophisticated and delicate equipment. Indigenous deminers are typically not trained as well as military personnel. This limits the use of equipment which requires extensive training. Until mines are eliminated, civilian use of the land for domestic, economic, and agricultural use is dangerous and destabilizing.[23]

III Current U.S. R&D Efforts

Each new day in the information age brings an opportunity to overcome technical problems that were previously impossible to solve. Individual technologies such as miniaturization, microelectronics, nano-technology, lasers, optics, focal-plane arrays, GPS, robotics, biotechnology, artificial intelligence, and digitization have the potential to radically improve mine warfare technology. An improved understanding of the science behind these technologies enhances the ability to link them with other technologies. This linkage has the potential to change mine warfare beyond recognition. In addition to the technical feasibility, there is strong public and government interest in solving these problems. Combined with increased funding and direction, new technical solutions are now possible.[24]

Alternatives to Mines

Since current APL Policy calls for the elimination of all APL, except for mixed systems, the U.S. has begun research on alternatives to anti-personnel landmines. Two approaches seem plausible. Non-lethal technology is one that would eliminate permanent casualties caused by APL. The desired effect of this non-lethal technology is temporary disability of personnel. Stun guns are an example. Command verification of a lethal technology is the other approach. It would eliminate unintended casualties caused by APL by verifying the target before detonation. Desired aspects of the command verified approach include increased

lethality and accuracy while eliminating unintended casualties.[25] The Intelligent Minefield (IMF) ATD for the Rapid Force Projection Initiative provides some idea of how this system might operate. Designed to provide light forces with an anti-armor and force multiplier capability, the IMF consist of Hornet munitions linked to controllers. The Hornet is a fielded munition that detects enemy armor with acoustic and seismic sensors, then attacks from the top. Although an anti-tank munition, a similar capability could be developed for anti-personnel use. The controller unit would provide the command verification link.[26]

Countermine

In order to discriminate a mine from metal clutter or to detect a non-metallic mine, several types of sensors must be combined (sensor fusion) to overcome the limitations of any single detection technology. Better computers and software are required to integrate and improve the analysis of this multiple sensor input (signal processing). Two types of detection are needed in the countermine arena. The first is a standoff capability to rapidly identify minefields. The second is a standoff capability to locate individual mines at operational speeds.[27]

To provide standoff minefield.detection, the Airborne Standoff Minefield Detection System (ASTAMIDS) is being developed. This system will use a combination of passive infrared and active laser sensors mounted on an unmanned aerial vehicle

(UAV). These sensors will transmit information to a ground based processor where the information will be interpreted and sent to commanders.[28]

In terms of standoff capability for mine detection, the Handheld Standoff Minefield Detection System (HSTAMIDS) is being developed for dismounted troops. This system will combine miniaturized forward looking infrared, electromagnetic induction (EMI), and ground penetrating radar (GPR) sensors on a handheld wand. Information from the sensors will be processed on a backpack computer.[29] A similar array of sensors will be mounted on a remote controlled vehicle for mounted troop movements along supply routes. Initially this capability will be provided by the Interim Vehicle Mounted Mine Detector (IVMMD) until the Ground Standoff Minefield Detection System (GSTAMIDS) can be fielded.[30]

Another important challenge concerns the ability to breach minefields. To improve performance of current line charge systems, the Explosive Standoff Minefield Breacher (ESMB) is being developed. This system will use an explosive net rather than line charges to detonate more mines in the breach lane. At the same time mechanical breaching is being improved by the Grizzly, an armored breacher based on the M1 with a mine clearing blade and rake. To separate operators from dangerous mine clearing operations, robotic insertion technology is being evaluated. This technology has been used in a mine clearing prototype in Bosnia where the Panther, an M60 with mine rollers,

has demonstrated good potential. Another breaching device, the Bangalore Torpedo, will be replaced by the Antipersonnel Obstacle Breaching System (APOBS). The APOBS will use a rocket to propel an explosive line charge over the minefield for detonation to clear a lane.[31]

Commercial automation technology was also used in Bosnia to keep track of the millions of mines encountered.[32] The Battlefield Combat Identification System (BCIS) has the potential to merge minefield marking and reporting functions for digitized units. This system is designed to provide friendly identification of mounted and dismounted forces. Tied in with a controller in an intelligent minefield, soldiers and vehicle could pass through smart munitions without being fired upon.[33]

As countermine technology improves U.S. capabilities, traditional concepts and sequences of mine warfare are beginning to merge. The Joint Countermine (JCM) Advanced Concept Technology Demonstration (ACTD) will test a multitude of demonstration, prototype, and production countermine systems. One of the key systems to be evaluated is the Mine Hunter/Killer ATD designed to demonstrate the full spectrum of countermine functions at tactical maneuver speeds. Sensors on this system will include IR and forward looking radar mounted on a ground platform. In addition this ATD will demonstrate mine neutralization devices that include projectiles, shaped charges, and lasers. The system

will also distribute mine information to other friendly units in the area.[34]

Demining

The U.S. is already the world leader in demining assistance; nevertheless, a key aspect of current policy is increased funding, research, and development of demining technologies. Key technologies under development range from mechanical clearing systems designed specifically for humanitarian uses to nuclear quadrupole resonance or x-ray backscatter sensors to detect the explosives in mines. Used in conjunction with EMI, these types of sensors could eliminate or reduce the high false alarm rates.[35] U.S. scientists are also evaluating special chemicals to be used for the destruction of mines that can not be disarmed. Used in place of explosives, this technique would eliminate additional clutter in the search area.[36]

The Future Face of Mine Warfare

To fulfill the expectations of "Army XXI" or "Army After Next", radically different technologies for mine warfare, many currently under development, will be required. In terms of countermine procedures, advanced detection technologies based on sensor fusion and signal processing will overcome the inadequacies of any one sensor technology. This advanced detection capability will identify individual mines or entire minefields from a distance. Robotics will separate the human operator from the sensors and the danger. Intelligent minefields

will allow friendly soldiers and civilians to pass though unharmed while enemy soldiers are accurately targeted. Digitization will provide the ability to track and communicate minefield information to all units simultaneously. Armed with near-perfect situational awareness and vastly improved breaching and clearing tools, commanders will have maximum freedom of movement with minimum mine casualties.

Many of these advanced technologies will also have applications in demining. Using a wide-area minefield detector, deminers will be able to rapidly identify large areas that should be targeted for further investigation. Using advanced mine detectors and chemicals, deminers will be able to rapidly identify mines and neutralize them without causing additional metallic clutter. The dramatic increase in the speed of demining will significantly reduce the cost of demining.

IV The Way Ahead: Technology and the Implementation of U.S. APL Policy

The humanitarian aspect of U.S. policy endeavors to reduce civilian casualties and suffering caused by APL. The military objective is to protect the lives of U.S. military personnel by providing the tools necessary to fulfill world-wide responsibilities. The treaty objective seeks a responsible treaty to ban APL as soon as possible without compromising military responsibilities. While not a panacea, advanced countermobility

and mine countermeasure technologies could play a significant role in facilitating all three objectives of U.S. APL policy.

Countermobility

From a humanitarian perspective, these technologies will ensure that U.S. anti-personnel mines and munitions do not cause civilian casualties. SDSD technology already significantly reduces the potential for collateral casualties. These APL stay active for a maximum of 90 days and, therefore, do not accumulate over time like NOD APL. Once deactivated the expense, danger, and need for demining are eliminated. Until deactivated, however, these APL can still cause civilian casualties because they combine lethal force and indiscriminate victim activation. By eliminating the deadly force or indiscriminate activation, alternatives to APL would eliminate permanent civilian casualties. Because mines by definition are victim activated, the command verified APL alternative would not be classified as a mine but as a munition.

The military requires a system that performs the functions of APL, especially on the Korean Peninsula. Simulations predict that without APL, U.S. casualties would be 35 percent higher in a Korean conflict. Alternatives to APL would provide a means of eliminating these increased casualties from enemy offensive actions. Furthermore alternatives to APL would eliminate friendly military casualties caused by unintended contact with friendly APL.[37]

By reducing the tension between humanitarian and military concerns, alternatives to APL also facilitates the treaty aspect of U.S. APL policy. Eliminating indiscriminate casualties makes alternatives to APL a non-issue to the actors that want to ban APL. By performing the military functions of APL, alternatives to mines make the elimination of APL acceptable to the actors charged with military responsibilities. By eliminating APL, the U.S. would have a stronger position in negotiating a ban with other countries in the CD.

Mine Countermeasures

One of the most important humanitarian aspects of U.S. APL policy is the Demining 2010 Initiative. This initiative will raise $12 billion to remove an estimated 110,000,000 mines by the year 2010. To achieve this truly ambitious goal, advanced mine detection and neutralization technology is required. Using current technology this feat would take 1,100 years and $33 billion.[38] Improved detection technology is the key to accomplishing this goal. Combining nuclear quadrupole resonance or x-ray backscatter with EMI technology may greatly reduce false positives and speed up mine identification. Neutralizing these mines with chemicals rather than explosives will prevent additional clutter from interfering with EMI detectors. In creasing the speed of mine detection and neutralization will decrease the cost of demining.

In addition to facilitating APL policy, advanced demining technology would also facilitate U.S. national security and national military strategy. In shaping the international environment, the ability to rapidly return demined territory back to civilian populations would accomplish two goals. First, it would eliminate the destabilizing effect of mines on the entire fabric of a society. Second, it would allow normal economic functions to resume and to establish the foundations for further economic development. Economic development leads to prosperity which ultimately promotes all three core objectives of the current U.S. National Security Strategy.[39]

From a military perspective, current policy mandates the development of alternatives to APL to protect military personnel and civilians. With force protection at the forefront of military considerations, improvements in the mine arena clearly need to be balanced with improvements in the countermine arena. Enemy mines will continue to be present and advanced technology such as magnetic fuses will make them more dangerous. Standoff wide-area minefield detection technologies like ASTAMIDS are crucial to mitigating this threat. Once identified, systems like the Grizzly will breech these obstacles while keeping pace with other maneuver systems. Improved countermine technology like GSTAMIDS will minimize the problems mines cause on fragile but vital supply routes and rear areas. These areas would be important targets of an enemy seeking to attack U.S. forces through

asymmetrical means. In addition, mines are frequently an aspect of peace enforcement and peacekeeping operations - - operations that are often on the outer edge of perceived national interests. Improved countermine technology could save the life that would mean the difference between mission success or failure due to lack of public or Congressional support.[40]

Finally advanced countermine technology could also facilitate that part of U.S. policy concerned with a treaty that would ban APL without compromising military security. A radical improvement in countermine technology could have the effect of decreasing the perception of APL effectiveness. Actors would be much more inclined to give up APL and participate in a treaty if APL effectiveness was diminished. Studies suggest that mine use has declined when countermeasures have minimized their effectiveness.[41] In addition to motivating a party to participate in a treaty to ban APL, countermine technology also could play a role in verifying treaty compliance. Verification of arms control treaties is a traditional military function and clearly an aspect of shaping the international environment through peacetime engagement. Wide-area detection technologies and minefield database management systems would be instrumental in establishing base lines and verifying treaty compliance.[42]

Conclusion

The wide spread and indiscriminate use of APL by some actors since the 1960s has created humanitarian carnage that is unacceptable in the light of a post-cold war environment. Two solutions have emerged: ban APL and remove APL. Although the U.S. differs with the Ottawa Process on the timing and terms of a treaty because of military responsibilities, U.S. APL policy supports both solutions. The problem is that the technology to execute these solutions is currently not available or fielded.

The development of alternatives to APL is clearly one of the biggest technical hurdles preventing U.S. participation in the Ottawa treaty. While not necessarily a prerequisite for negotiating a treaty in the CD, it will be more difficult to convince other nations to renounce the use of APL if the U.S. does not. Alternatives to APL will ideally improve the military utility of APL while eliminating unintended casualties. This would end a divisive issue between the public, the government, and the military. An issue that will only grow more contentious as various target dates for APL elimination draw closer.

Even once an effective APL ban is in force, millions of emplaced mines need to be located and destroyed. Using current technology this process is very slow, dangerous, and expensive. The 2010 demining initiative can not achieve success without improved countermeasure technology. If the U.S.-led effort to develop and share new humanitarian demining technology is

successful, the promise of the Demining Initiative 2010 will be realized and the U.S. will regain the public perception of leadership in the APL arena.

Advanced detection capabilities would also have great military utility. Even with an APL treaty, the U.S. will face rouge adversaries with advanced mines. Although the U.S. currently has adequate breaching capabilities for now, there are no wide-area or real-time mine detection technologies. These inadequacies cause problems throughout the spectrum of conflict, but are exacerbated in Smaller Scale Contingencies (SSC) where force protection is especially important because of the weakly perceived national interests underlying these operations. Without improved countermeasure technology, mines pose a serious threat to force protection throughout the spectrum of conflict.

The technical advances described in this paper will not come at once and may take several years to fully develop. Priority should be given to ASTAMIDS, GSTAMIDS, HSTAMIDS, and other promising detection technologies. The first step in avoiding military or civilian casualties is to locate the mines. The current detection technology, an improved version of what was used during W.W.II, has not kept pace with requirements. A dramatically improved ability to detect mines is the most pressing need in humanitarian and military terms. The next priority should be given to advanced neutralization technologies. This is the second step in avoiding military and civilian

casualties. The third priority should go to alternatives to APL. This technology will reduce military casualties and facilitate U.S. participation in a treaty to ban APL, the third step in reducing military and civilian casualties.

These technologies are consistent with the direction of current APL policy. Not only will they facilitate current policy but also the transition to an information-age army. The opportunity to parlay the current interests and funding into the technical solutions we need to fulfill both requirements is at hand.

Word Count: 4594

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[29] Ibid.

[30] Ibid., 8-9. See also Browder, 2.

[31] For breaching, see Ibid., 2. Weapon Systems of the United States Army 1997, 193. David G. Knichel, "Robotics Insertion Technology," Engineer, 24 (August 1996): pg. 24-25.

[32] Taylor, MAJ, 14-16.

[33] For a description of BCIS see Weapon Systems of the United States Army 1997, 49.

[34] Ibid., 87-89.

[35] Horowitz et al., 3-4.

[36] Rouhi, 21.

[37] BG Bruce K. Scott, "Anti-Personnel Landmine (APL) Study by the US Army Concepts Analysis Agency," Information Briefing, Washington, D.C., 12 June 1997.

[38] Leary, 13.

[39] Janzon and Sarholm, 45. See also The White House, A National Security Strategy for a New Century, Washington D.C.: GPO, May 1997, i, 18.

[40] For mine problems in rear areas see William C. Schneck, Malcolm H. Visser, and Stuart Leigh, "Advances in Mine Warfare: An Overview," Engineer 23 (April 1993): 6.

[41] International Committee of the Red Cross, Anti-Personnel Landmines - Friend or Foe? (Geneva, March 1996), 68.

[42] Chairman of the Joint Chiefs of Staff, National Military Strategy of The United States of America, Washington, D.C.: GPO, 1997, 13.

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